

Maintenance Systems Formation

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Summary: The major topics dealt with in this paper include identification of items to be maintained under a preventative maintenance schedule (PM) in a facility and the assessment of the criticality of each of the nominated items of plant. Based on the asset listing a preventative maintenance schedule and inspection plan, covering simple inspection, trade level overhaul tasks and condition monitoring tasks may be established. Supporting the schedule are requirements for sub-contractor agreements and services, and statutory registers. Where possible recommendations on critical spares holdings and best practice maintenance policies should be supplied. The whole process is managed with a planning and scheduling approach, and measured by KPIs for reporting maintenance performance.

1.0 INTRODUCTION

The major steps in the maintenance systems development include the assessment of the criticality and performance of each of the nominated items of plant. This will form the basis for maintenance and process improvement analysis. Identification of the plant equipment hierarchies involves demonstrating parent child relationships for cost analysis and performance analysis purposes. This is a strategic aspect of the system since getting the plant dictionary right is necessary for the remainder of the maintenance system to work well.

Reliability analysis, identifying a risk-based priority for a maintenance strategy, based on an understanding of the failure modes sets priorities for analysis of preventative maintenance (PM) procedures based on a reliability block diagram / production criticality overview. The preventative maintenance schedule and inspection plan, covering operator level inspection, trade level overhaul tasks is developed using a reliability-centered maintenance (RCM)-based strategy to schedule overhaul and discard tasks, and condition monitoring tasks (again using RCM methodology to assess failure modes to be detected). An aspect of this work is to incorporate in requirements from manufacturer recommendations, Standards and statutory obligations

Work management policies should cover the following:

- Planning and scheduling
- Work raising, management and acquittal
- Call outs
- Developing new procedures

2.0 PLANT DICTIONARY

The establishment of the plant dictionary has a number of associated tasks:

1. Overall process for the facility – what is the departmental breakdown
2. Operations requirements formulation – standard interview process and documentation
3. Past maintenance practices analysis
4. Criticality assessment – conducted in conjunction with Process Mapping

Initial site visits to the facility will provide the following information:

1. Full details of the current plant dictionary if already loaded into a computer system
2. Appreciation of plant layout
3. Information on current plant maintenance practices
4. Understanding of types and diversity of assets
5. Understanding of criticality and reliability of assets

Process mapping is a means by which a complex machine or system of machines is broken down into a logical hierarchy of maintainable items. A maintainable item is defined as an item for which an inspection is warranted to determine if it could failure in the foreseeable future and that failure leads to an undesirable outcome that will require an immediate response. A sample process map is shown in Figure 1, identifying maintainable items within the flow of the process stream.

Maintainable item criticality criteria are tabulated from least consequence to worst. This is intended to assist Planners and supervisors with set priorities for work orders.

The logic for building a plant dictionary at the start follows:

1. We need to conduct PM checks on items of equipment
2. One of the PM work orders we need to raise is the inspection of selected items of plant
3. What do we look at in each item of plant
4. The plant item is made up of a number of sub-systems, so we need another tier to the second level to organise or sort the maintainable items
5. What are the maintainable items that need to be checked

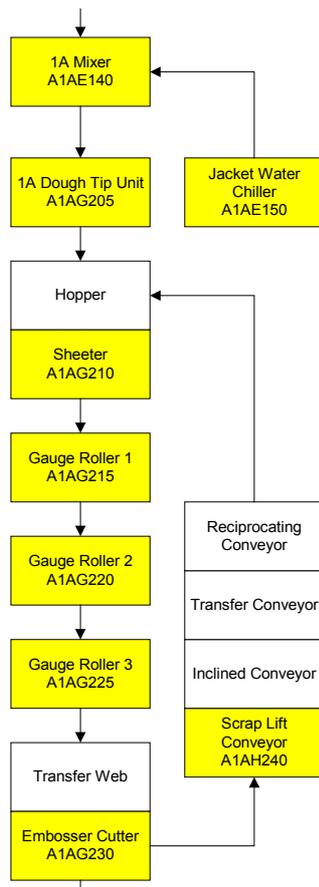


Figure 1 Process map extract

An extract of a facility plant dictionary is shown in Figure 2. This exhibits the hierarchical nature of the plant dictionary.

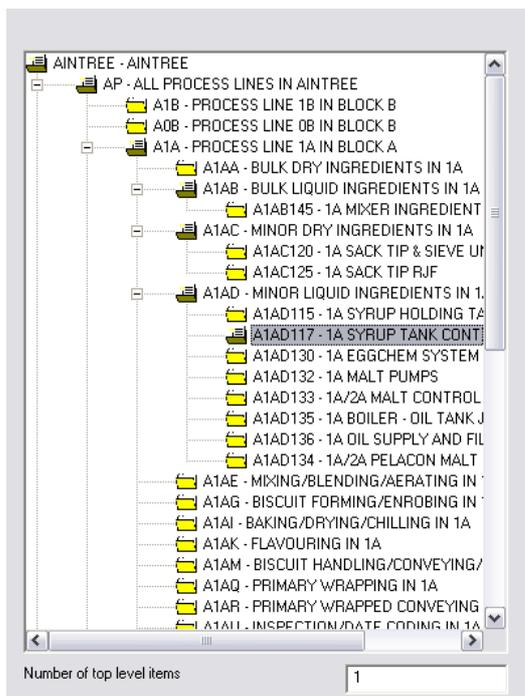


Figure 2 Sample plant dictionary

An important note to consider here, which is a tip for later stages of the work:

- A check is a quick visual inspection that is intended to identify anything obviously wrong
- An inspection should have a check sheet accompanying it and is intended to provide feedback that can be trended over time
- A PM task is one where someone may check, inspect or conduct a time based action which will prevent a failure

3.0 PROCEDURES WRITING

The relationship of maintenance strategies to procedures and routines is identified in Figure 3. A maintenance procedure must describe what has to be done but not how to do it. It is important that the competency of the trades staff is respected and taken into account so that the procedures can be used as simple check lists rather than cumbersome and difficult to read documents, that may well be ignored by the trades person.

What has to be done means that the following is covered:

1. Items to be lubricated are listed and specification of the lubricant is provided
2. When checks are to be made, the upper and lower limits of acceptability are provided – this is particularly important for electrical checks
3. The difference between a check and an inspection is that an inspection means that a measurement has to be recorded – a check means that the trades person views something to ascertain whether it is OK or not. Hence if an inspection is required ensure that an inspection sheet is provided as part of the procedure
4. If alignment or balancing or similar work is required, then nominated points of measurement have to be provided, possibly requiring the trades person to write down clearances or dial readings on an inspection sheet

It is very important that Mechanical and Electrical procedures are distinguished from each other. Other categories of procedures can include Lubrication, High Voltage and other specialised trades, eg Plumbers, Civil, etc. We should not assume multi-skilling at a site, even if that makes sense, without checking with the maintenance staff on their standard practices.

It is common practice not to load into the Master Maintenance Schedule and thereby into the work management system routines with a periodicity more frequent than monthly. Fortnightly routines need to be treated on a case-by-case basis, but these are less commonly used than weekly and monthly frequencies. Daily and weekly routines are thereby treated as Standard Operating Procedures (SOPs) and are expected to be part of people's standard job.

There should be no need for a work order to be issued for this work to be initiated. However we still write the procedural description of the task list, and provide this in a compiled set of SOPs that are handed over at the same time as the procedure set loaded into the work management system.

A procedure with its set of attendant operations is shown below. Key information associated with the procedure includes the resource type, expected duration of the work, whether the machine is running or not running, and the strategy grouping of the procedure.

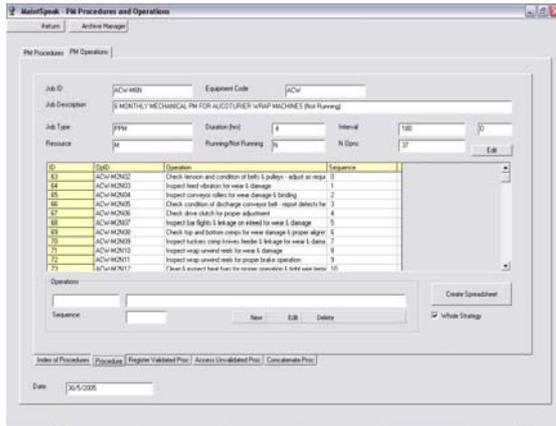


Figure 3 Design view of maintenance procedure

Procedures must be written to assist electronic load-up into the work management system. Hence they will need to be written in the first instance in a format and media that facilitates this process. Additional or supplementary information on procedures should include:

1. List of materials that may be used in the procedure – this is called the Bill of Materials and should include the name of a spare part, the stock code and the Manufacturer. Possibly also the Manufacturer’s item identifier code should be listed as well.
2. Access requirements – this is particularly important for isolations but may also include what has to be done to access a building (eg security requirements), or if other equipment has to be removed or isolated first
3. Documentation – drawing numbers, software version numbers, where manuals are located, etc
4. Consumables – these are not items to be included in the Bill of Materials but are purchased material that may be used. This would include all lubricants and any disposable items.

4.0 PLANNING AND SCHEDULING

The overall view of a maintenance planning and scheduling system is shown in Figure 4. This identifies the key elements that are necessary for a

well-controlled maintenance system. Key characteristics of a good system are set out in order of priority from most important to very important:

1. Understanding of the plant processes – what is important out there and when can access be optimised
2. Use of the works management system – functionality, flexibility, reporting, data integrity
3. Project management – understand critical path, set priorities, resource planning/leveling (what can we do with the people we have)
4. Communication – run planning meetings, negotiate access to plant and services, communicate backlog, risk and the strategy to get through the work

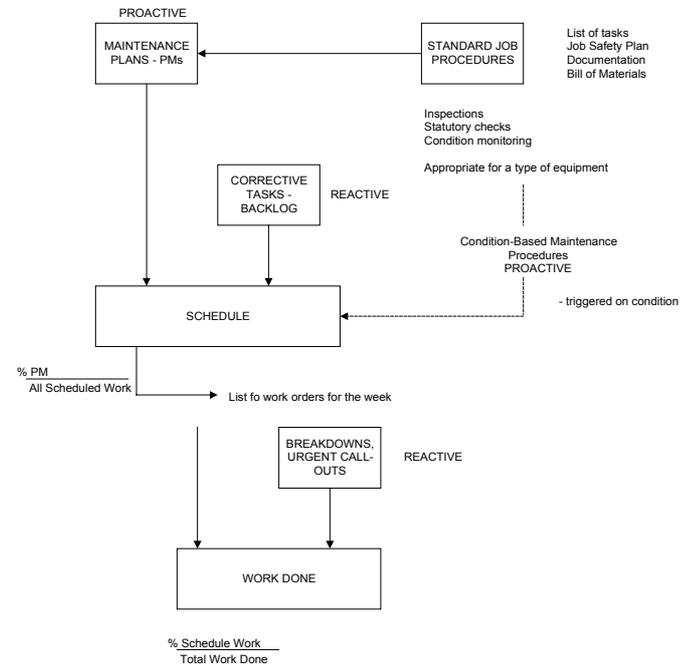


Figure 4 Planned and scheduled maintenance system

Note that breakdowns are not the province of the Planner/Scheduler – they are the responsibility of the team leaders or departmental trades people, who have to organise a response. However the Planner/Scheduler may get involved if these people need access to site services, third parties etc. Secondly, the Planner/Scheduler will support the budget and procurement, and is expected to provide a report to assist whoever is responsible for this, and is expected to organise spares availability.

5.0 REPORTING

Routine reporting of key performance indicators (KPIs) form the basis of the monitoring process for performance-based maintenance. Maintenance technical performance may be assessed by the following measures:

1. Frequency of work orders per week on a rolling 12 month basis
2. Numbers of work orders sorted by Unit basis
3. Pareto analysis of work orders on a Unit basis
4. Downtime frequency per week sorted by Unit on a rolling 12 month basis
5. Pareto analysis of equipment downtime hours
6. Monthly downtime report – tabular format of lost time incidents

Example plots are shown below:

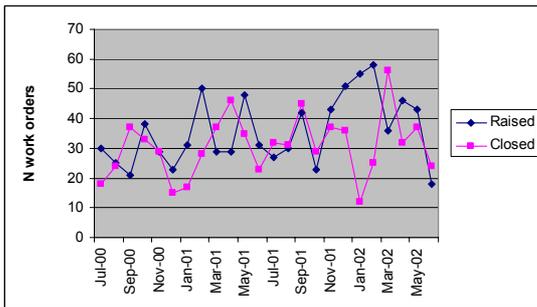


Figure 5 Sample work order frequency plot

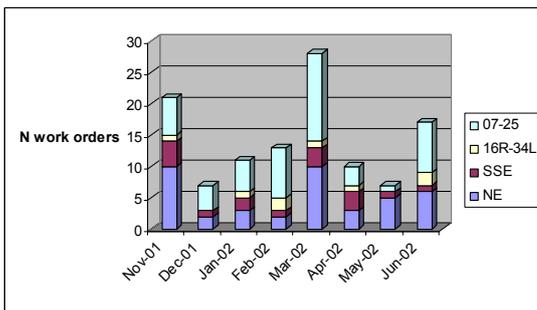


Figure 6 Sample number of work orders

Backlog analysis is a Key Performance Indicator (KPI) can show the risk outstanding with planned but incomplete maintenance work. The backlog report is a tool to distinguish between acceptable and high-risk responsiveness to work requests. The report will also show the specific tasks that are threats to the assets or may need their criticality changed over time.

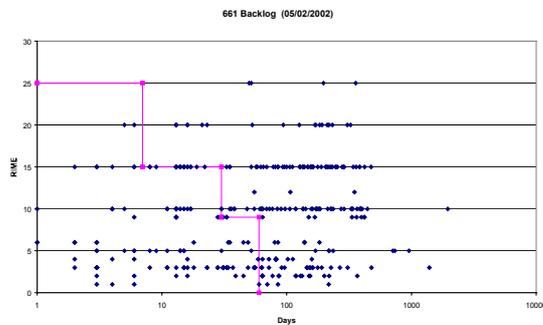


Figure 7 Sample backlog report

Each point on the plot is a work order, and the x-axis refers to the days outstanding between when the task

was raised and the date of the analysis. The y-axis is a measure of the risk of the work order, with 25 representing maximum possible exposure. The area to the left side of the staggered line is the acceptable performance area, where the time in backlog is considered acceptable given the criticality of the task. But the other side of the policy line identifies tasks that are risks to the assets or need their criticality to be reviewed over time.

6.0 CONCLUSION

The technical processes in establishing a maintenance system include technical procedures improvement, inspection management, reliability analysis, works management system uptake and improved use, including planning and scheduling of work, and support for labour management. The end objective of this work is to assure that the maintenance team has the necessary systems and technical processes to assist a consistent and well founded approach to maintenance, covering use of the works management system, a thorough maintenance plan and a mixed resource base combining in-house and contract labour. Tangible deliverables of this work include:

- Consistent and well structured plant dictionaries within the works management system, with appropriate criticalities of plant identified
- Significant improvement in the technical quality of procedures
- Wider use of inspections and reliability analyses
- Planning and scheduling methods improving the levels of planned work
- Management reporting and KPIs

The processes described in this paper and the maintenance system design software are available as services provided by Covaris Pty Ltd.